

NOTES ON SOME RECENTLY DISCOVERED OCCURRENCES OF THE PSEUDOMORPH, GLENDONITE.

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(Six text-figs.)

While examining the Lower Marine Series along the main northern road, in the vicinity of Harper's Hill (Allandale), I observed a number of specimens of the pseudomorph, Glendonite, in two large boulders by the roadside. These were thought, at the time, to have been carried there from some other locality, but inquiries, made of some of the residents, showed that they had come from the road-cutting close by. Further search was then made, and specimens were soon found *in situ*. This discovery was of considerable interest, for, although glendonite had been recorded from a number of localities previously, all the occurrences were in

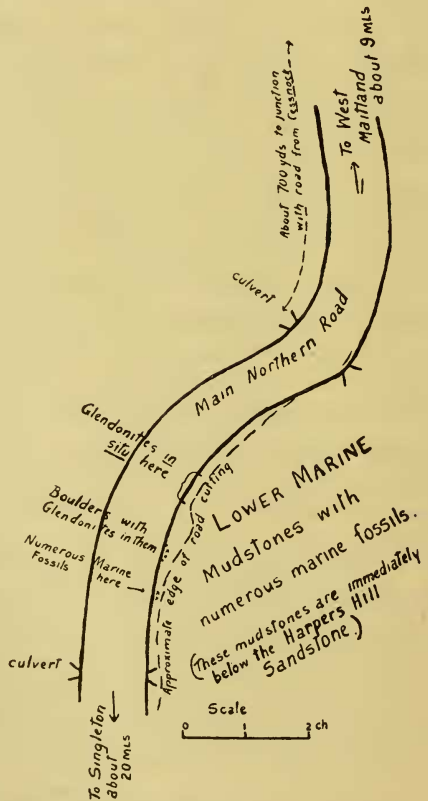


Fig. 1.—Sketch showing locality where Glendonites were found in the Lower Marine Series.

the Upper Marine Series, and it had never been found in the Lower Marine Series. A number of specimens were collected, and examined to see whether they presented any differences from those previously described. Mr. W. S. Dun kindly exhibited specimens of these crystals for me, at the meeting of this Society held in August, last year.

In a paper on "The Occurrence of the Pseudomorph Glendonite in New South Wales," by Professor David, Dr. Woolnough, and Messrs. Taylor and Foxall,* a complete review of previous literature was given; and for a bibliography, the reader is referred to that paper. They described the occurrence of glendonite at four localities, representing four separate horizons in the Upper Marine Series, as follows†:—

(a) Glendon, 5 miles E.S.E. from Singleton. Horizon approximately 200 feet above the Muree Beds. The glendonites here occur singly or in groups, and are from 3 to 12 inches in length.

(b) Left bank of Hunter River, at Railway Bridge, Singleton. Horizon about 1,000 feet above the Muree Beds. One glendonite recorded from here, is composed entirely of ferruginous gypsum.

(c) Mount Vincent, 14 miles south of East Maitland. Horizon 700 feet above the Muree Beds. The glendonites here frequently take the form of hollow casts in the centre of an oval or elliptical concretion. They occur singly or in aggregates.

(d) Huskisson, Jervis Bay. Horizon about 200 feet below the Nowra Grit, which is the equivalent of the Muree Beds.

The size varies from an inch to over fourteen inches in length.

In 1908, Mr. J. E. Carne‡ discovered glendonites on another horizon, in the Upper Marine Series, namely, about 350 feet above the top seam of the Greta Coal-Measures at Muswellbrook. These glendonites are of the large type, measuring up to 9 inches and

* Records Geol. Surv. N. S. Wales, 1905, viii., pp. 161-179.

† The following details of these four horizons are taken from the paper mentioned above, pp. 166-169.

‡ Ann. Report Dept. of Mines N. S. Wales, 1908, p. 166. (The plan and sections accompanying this report, were printed in the Annual Report for 1910, facing p. 176).

more in length, and 2 to 3 inches in diameter. Both simple and compound types occur, the latter being apparently haphazard intergrowths of two or more individuals.

In 1910, Dr. W. G. Woolnough* discovered a zone of glendonite pseudomorphs in an argillaceous limestone, on the road from Singleton to Dyrring, near the southern branch of Wattle Ponds Creek. This horizon is about 1,480 feet below the base of the Muree Beds. The crystals there are of the small, composite type.

During 1912, Professor Woolnough† found glendonites associated with *Chaenomya* in the topmost part of the Upper Marine Series at Wollongong. These were in the form of hollow moulds in the centre of concretions, similar to those which are found at Mt. Vincent. The base in which these concretions occur, is a tuffaceous sandstone.

In his report on "The Tasmanite Shale-Fields of the Mersey District," Mr. W. H. Twelvetrees‡ has recorded the occurrence of glendonite in the mudstones above the Tasmanite Shale-deposit. The Shale is considered, by him, to be on the same horizon as the Greta Coal-Measures in New South Wales, so that the horizon of the glendonite-occurrence in Tasmania, corresponds to the lower part of the Upper Marine Series in New South Wales. In the only specimen that I have seen from the Tasmanian locality, the glendonites are of the smaller type, and are bunched together in complex aggregates.

The occurrence which forms the main subject of this note, is on the main northern road, nearly half a mile beyond the junction of that road with the road from Allandale Railway Station. (See sketch, Fig.1, p.160).

The horizon of these beds is 2,800 feet above the base of the Lower Marine Series, and is nearly 2,600 feet below the lowest recorded horizon. It is about 150 feet below the well-known Harper's Hill, green, tuffaceous sandstone.

* Journ. Proc. Royal Soc. N. S. Wales, 1910, xliv., pp.557-559.

† Professor Woolnough very kindly gave me this information of his discovery at Wollongong.

‡ Dept. of Mines, Tas., Geol. Survey Bulletin, No.11, 1912, p.54.

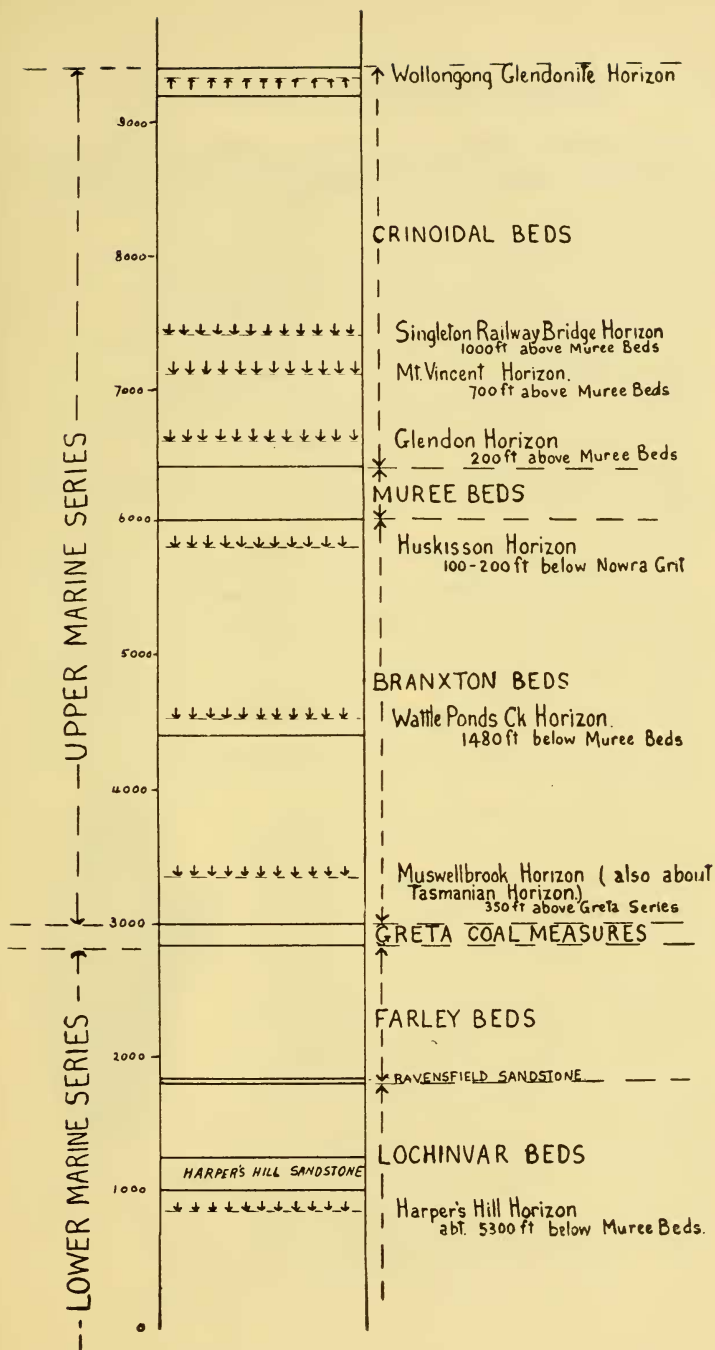


Fig. 2.—Vertical Section of part of the Permo-Carboniferous System, showing glendonite-horizons.

The glendonites here are imbedded in a light-coloured, micaceous mudstone, which is rather calcareous, and contains numerous marine fossils, *e.g.*,

Plant-st em.	<i>Maonia</i> , 3 spp.
<i>Spirifer vespertilio</i> G. Sby.	<i>Pleurophorus</i> sp.
<i>S. tasmaniensis</i> Morris.	<i>Pachydomus</i> sp.
<i>Martiniopsis subradiata</i> Sby.	<i>Mourlonia rotundata</i> (?).
<i>Chaenomya</i> sp.	<i>Keeneia</i> (juv.).
<i>Edmondia</i> (?) <i>nobilissima</i> de Kon.	<i>Conularia laevigata</i> Morris.
<i>Deltopecten subquinelineatus</i> McCoy; two vars.	

Fig. 2 (p. 163) is a vertical section of part of the Permo-Carboniferous system, showing the position of the various glendonite-horizons.

Chemical.—The substance of these pseudomorphs was found to be almost entirely soluble in hydrochloric acid; and qualitative analysis showed that they consist almost wholly of calcium carbonate, and also that there is an absence of both sulphates, and barium. The composition, then, is no doubt very similar to those analyses by Mr. B. V. Barton, B.E., quoted in the paper mentioned above,* and a quantitative analysis was not considered necessary in this case.

Crystallographic.—The crystals are all of similar type to those described from Singleton and Glendon, but are somewhat smaller, averaging from 2 to 2·5 inches in length and 0·75 inch in diameter. They are mostly simple crystals, but a number are of the composite type. Of those which are not simple, the majority are like that figured (Fig. 4), *i.e.*, an intergrowth of two individuals, while a few are much more complex, there being as many as eight individuals bunched together. The frequent occurrence of the first of these two types, namely, intergrowths of two individuals, suggested the possibility of twinning. That they are not twinned, however,

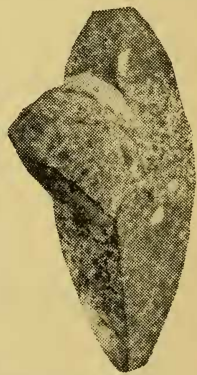


Fig. 4—Photo of simply twinned glendonite crystal (about nat. size).

* Rec. Geol. Survey N. S. Wales, viii., pp. 170-172.

seems to be shown by the fact, that an examination of three different specimens of this type, showed the relative orientation of the two individuals to be different in each case.

The crystals all show distinct curving of some of the faces; the prism-faces are generally plane, and give straight edges, but the pyramid- and dome-faces are decidedly curved. In measuring the curved faces, the method used by Anderson and Jevons,* in measuring opal-pseudomorphs from White Cliffs, N.S.W., was followed, namely, "making the goniometer-arms tangent to the part of the faces close to the edges."

Glauberite has been suggested as the probable original mineral for these pseudomorphs, and all the measurements of these crystals, from the Lower Marine Series, tend to confirm that suggestion.

The habit is monoclinic, and measurement shows that there are three forms present, the angles between homologous faces of which are, 94° , 63.3° , and 67° . These three forms correspond fairly well with with $m(110)$, $s(111)$, and $f(023)$ of glauherite. Two of these forms were described on the crystals from Huskisson,† but on these crystals, the clino-dome present was $g(021)$, while on the crystals now being discussed, the clino-dome is $f(023)$. The following table shows the measurement of interfacial angles, compared with those of glauherite:—

Normal Angles.	No. of readings.	Limits.	Mean.	Average.	Angles for Glauberite
$(1\bar{1}0) \wedge (110)$	9	$91^\circ-97^\circ$	95°	94°	$96^\circ 58'$
$(\bar{1}10) \wedge (\bar{1}\bar{1}0)$	8	$90^\circ-94\frac{1}{2}^\circ$	92.3°		
$(111) \wedge (1\bar{1}\bar{1})$	8	$59\frac{1}{2}^\circ-67^\circ$	63.6°	63.3°	$63^\circ 42'$
$(\bar{1}\bar{1}\bar{1}) \wedge (\bar{1}\bar{1}\bar{1})$	9	$60\frac{1}{2}^\circ-66\frac{1}{2}^\circ$	63.1°		
$(023) \wedge (0\bar{2}3)$	9	$63^\circ-68\frac{1}{2}^\circ$	66.3°	67°	$64^\circ 46\frac{1}{2}^\circ$
$(0\bar{2}3) \wedge (02\bar{3})$	9	$64^\circ-70^\circ$	67.7°		

* Rec. Austr. Museum, vi., 1905, p.33.

† *Op. cit.*, p 175.

The measurement of the angles between s and f , and s and m was too unsatisfactory, on account of rough and curved surfaces. Fig. 3 is an ideal stereographic projection of one end of a crystal with the three forms developed.

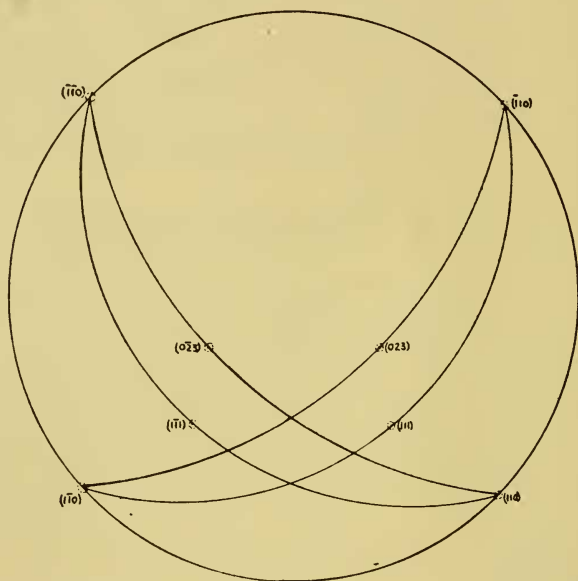


Fig. 3.—Stereographic projection of one end of a glendonite-crystal.

A number of the crystals show a series of parallel striations, representing the trace of a cleavage (Figs. 5-6). In some cases, these striations persist along the whole length of the crystal, over forms which are not in one zone, and so cannot represent oscillatory combinations. The angle between the plane of these striations and the edge $(110)(\bar{1}\bar{1}0)$, was easily calculated, and proved to be approximately 66° . If the original mineral were glauberite, the cleavage is perfect, parallel to (001) , so that the angle just measured, would represent β . In glauberite, β is $67^\circ 49' 7''$, so that the angle obtained for these glendonites, is quite as close as could be expected from contact goniometer-measurements.

Petrology.—Only one crystal was sectioned for the microscope. It consisted almost completely of granular calcite. A small proportion of the calcite-grains are clear and colourless, but most of them are of a cloudy-brown colour. A few small fragments of quartz were observed.

Summary and Conclusions.—All the observations made on these glendonites from the Lower Marine Series, confirm the conclusion

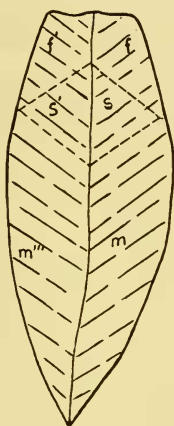


Fig.5.—Freehand drawing of glendonite crystal, showing direction of striations (front view : about nat. size).



Fig.6.—Same as Fig.5 (side view : about nat. size).

arrived at by Professor David, Dr. Woolnough, and Messrs. Taylor and Foxall, that the original mineral, of which they are replacements, was glauberite.* Nothing has been observed which conflicts with their conclusions, excepting numbers (v.) and (vi.).†

With regard to (v.), which is as follows, "The presence of numerous erratics indicates that these waters were occasionally chilled by floating ice," it may be stated, that three, of the four newly-discovered occurrences of glendonite, are on horizons which

* *Op. cit.*, p.179.

† *Op. cit.*, p.178.

are not considered to have been formed under glacial conditions. The newly-discovered occurrences also do not agree with the statement in conclusion No. (vi.) that "The horizons of the glendonites are not far below, in some cases close to, the top of the highest beds of a Marine Series, etc."

Glendonite has now been recorded from seven horizons in New South Wales, and one in Tasmania. These horizons are scattered at intervals, through a thickness of strata amounting to about 7,000 feet. This shows that the conditions, which governed the crystallisation of glauberite (for it is almost certain that this was the original mineral), must have been of fairly frequent occurrence in the Permo-Carboniferous seas; and it also shows that the occurrence of the pseudomorphs is of no value as an indicator of any particular stratigraphical horizon.

Glacial conditions were of frequent occurrence during Permo-Carboniferous time, and Professor Woolnough has suggested, in conversation about these pseudomorphs, that these conditions may have played an important part in the production of conditions suitable for the formation of glauberite; and that if this could be established, then the occurrence of glendonite, pseudomorphic after glauberite, might be taken as an indication of glacial conditions. This suggestion, taken with the fact that the glendonites always occur in a calcareous mudstone, opens up an interesting field of research in the artificial preparation of glauberite, (which, as far as could be ascertained, has not yet been prepared artificially in the wet way), by attempting to grow the crystals in calcareous mud, under temperature-conditions approximating to those which would be prevalent in waters subject to chilling by glaciers.

I wish to express my thanks to Dr. C. Anderson, of the Australian Museum, for the advice he most willingly gave me in connection with the crystallographic part of this note; and to Professor Woolnough for kindly volunteering part of the information contained in the paper, and for suggestions made in discussing the subject with me.